



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

EVALUATION OF GLYPHOSATE INJECTION AND CUT
SURFACE TREATMENTS TO CONTROL TALL-GROWING
VEGETATION ON POWERLINE RIGHTS-OF-WAY
IN BRITISH COLUMBIA

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August 1983

CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT

OPERATIONS ENGINEERING DIVISION



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Canadian Cataloguing in Publication Data

Roddick, René G.

Evaluation of glyphosate injection and cut surface treatments to control tall-growing vegetation on powerline rights-of-way in British Columbia

Includes bibliographical references.

ISBN 0-7719-9309-9

1. Plants, Effect of glyphosate on - British Columbia. 2. Weed control - British Columbia - Biological control. 3. Electric lines - Overhead - British Columbia - Right-of-way. I. Miller, A.V. II. B.C. Hydro. III. Title.

SB952.G58R62 1983

632'.58

C83-092263-6

ABSTRACT

Efficacy of glyphosate herbicide injection and cut surface application was evaluated for Acer circinatum, Acer macrophyllum, Alnus rubra, Betula papyrifera, Populus trichocarpa, Pseudotsuga menziesii, and Thuja plicata. The study area was confined to powerline rights-of-way in the Lower Mainland and Fraser Valley areas of British Columbia. Results indicate excellent control was achieved on all species tested.

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INTRODUCTION

Past practices of vegetation control on rights-of-way (ROW) relied mainly on tree slashing and broadcast herbicide applications to control unwanted species. At B. C. Hydro the trend has been to minimize or even eliminate broadcast herbicide programs which have fueled public controversy and have not effectively preserved desired vegetation. Aerial herbicide applications on B. C. Hydro ROW are very rare and utilized only in remote and inaccessible areas. The science of vegetation management has progressed to an integrated approach with specific goals attained by following prescribed techniques. A stable state community of low-growing shrubs and herbaceous plants and grasses is the most desirable, although not exclusive scenario. To achieve this biological control, combined physical and chemical control techniques are used.

Due to prolific regeneration by the most troublesome deciduous tall-growing trees on ROW, the judicious use of site and species-specific herbicides is needed to effect biological control. The environmental damage or contamination from these methods, hack and squirt, capsule injection, and cut surface treatments are negligible, especially when the chemical applied is glyphosate. As glyphosate is readily bound to clay particles and organic molecules and can be very

effective when applied correctly, it is compatible with the conditions found on the ROW in the Lower Mainland and Fraser Valley areas of British Columbia.

Since these application techniques require additional data for registration and conventional chemical alternatives are not feasible, brush control programs in the Lower Mainland, Fraser Valley, and many other coastal areas of B. C. have been relegated to slashing crews. The regenerative, coppice-forming nature of Alnus rubra - red alder, the predominant target species, compounds the problem of control. Chemical programs in the study area have been solely experimental. Initial field observations exhibit excellent results. In the studies, three selective methods of glyphosate application are considered:

- hack and squirt;
- capsule injection; and
- cut surface application.

The species-specific application of these methods allow for treatments near water bodies and are less objectionable in populated areas.

PURPOSE

The purpose of these experiments is to supply data to substantiate the registration of glyphosate injection and cut surface treatment on the industrial label. The following objectives have been included in the research:

1. Evaluate the effectiveness of hack and squirt, capsule injection, and cut surface applications of glyphosate as a factor in the following:
 - (a) Maintenance of line security;
 - (b) assurance of worker safety;
 - (c) prevention of fire;
 - (d) enhancement of vegetation for wildlife cover and forage; and
 - (e) reduction in herbicide impact on non-target species.
2. Familiarize contractors, regional ROW supervisors, and their staff with a greater range of techniques.
3. Evaluate the on-the-job practicality of the new application techniques.

The field trials are authorized by the following provincial research permits:

1. Permit No 105-156* RES-81/83 - hack and squirt in the Haney, B. C. area;
2. Permit No 105-157* RES-81/83 - capsule injection in the Agassiz, B. C. area;
3. Permit No 105-164* RES-81/84 - hack and squirt in the Harrison Hot Springs, B. C. area; and
4. Permit No 105-165* RES-82 - hack and squirt, cut surface treatment, and capsule injection in the Harrison Hot Springs, B. C. area.

METHODS

Trial sites were selected which were scheduled for maintenance and were deemed adequately isolated for research. Water bodies were surveyed and identified within the guidelines of provincial permits. Where feasible, requests were made for authorization to treat within the 10 m Pesticide Free Zone normally stipulated by the B. C. Ministry of the Environment.

All plots were approximately 13 m x 3 m and selected where overhead conductors could be used for orientation. Selection was biased towards sites which were accessible and which supported an abundance of

low-growing vegetation and tall-growing trees. Five to six plots were chosen for each treatment. The control plots for the injection techniques were selected on the same ROW. The control plot for the cut surface application was selected from a tower site thought to be representative of the study area.

The contractors were familiarized with the techniques at pre-job conferences and were provided with Conductor to Terrain Clearance (CTC) reports, patrol maps of the transmission line, safety information, handling instructions, and application information for glyphosate.

The contractors were instructed to treat only the following target species:

- | | |
|--------------------------------|-------------------|
| - <u>Acer circinatum</u> | vine maple |
| - <u>Acer macrophyllum</u> | bigleaf maple |
| - <u>Alnus rubra</u> | red alder |
| - <u>Betula</u> spp | birch |
| - <u>Populus trichocarpa</u> | black cottonwood |
| - <u>Pseudotsuga menziesii</u> | Douglas fir |
| - <u>Thuja plicata</u> | western red cedar |
| - <u>Tsuga heterophylla</u> | western hemlock |

The following methodology was adopted:

1. Hack and Squirt - notch target species at waist height and immediately apply:
 - 1 to 2 ml of 14% glyphosate in thickening agents with dye for each 2.54 cm diameter at breast height (dbh)
 - 1 to 2 ml of 1% glyphosate in diesel oil for each 2.54 cm dbh.
2. Capsule Injection - inject one capsule containing 0.2 g a.i. glyphosate into cambium for each 2.54 cm of dbh at less than 20 cm from the ground. Each stem 2 cm diameter or greater is treated.
3. Cut Surface Treatment - completely sever the stem to less than 20 cm height, apply 1-2 ml of 14% glyphosate in thickening agents and dye per 2.54 cm dbh to the cambial tissue immediately after cutting, i.e. within seconds.

RESULTS

General field observations and data (Tables 1-5) indicate that A. rubra is the predominant species in the study area. Other species such as A. macrophyllum, A. circinatum, and P. trichocarpa were evident in moderate numbers while B. papyrifera, I. plicata and P. menziesii were sparsely distributed. I. heterophylla was not found in the study area.

Symptomology

Except for cut surface applications, where all foliage is removed, symptoms were observed within two weeks of application. A. rubra exhibited curled and chlorotic leaves at the distal tips of branches, followed by interveinal necrosis and finally total foliar necrosis. Stems reacted with vertical blackened streaks that led from the notch towards the top. In advanced cases the bark split and peeled. Samples of the bark showed the cambium had changed from green to brown. The following spring a few trees flushed and produced dwarfed leaves, others produced normal leaves from a few apparently unaffected branches.

The foliar symptoms were also evident in Acer spp, Betula spp, and Populus spp, although only the Betula spp reacted with peeled bark.

In coniferous species, symptoms progressed from drooped terminal branches and leaders to chlorotic needles or scales and finally to necrosis of the foliage. No recovery was observed except for two individuals of T. plicata which had received improper doses.

For the purposes of evaluation, trees with no foliage were recorded as controlled, the remainder with dwarfed or limited foliage were recorded as not controlled.

Techniques

The hack and squirt technique was modified during the program. At the outset of the program, cuts were made at waist height and higher. This was amended to waist height and below since the earlier treatments were not always effective on the lower branches. The lower branches were removed in the trials for Permit No 105-165* RES-81/83.

The capsule injection methodology was also modified during experimentation. This method was more efficient when capsules were attached to the area just above the root crown and to crotches of multiple stems. The timing of injection into A. macrophyllum was also adjusted as March treatments appeared to be ineffective (Dillistone, B., 1983).

Harrison Hot Springs (Permit No 105-165* RES-82)

This Harrison Hot Springs site had a representative trial for each technique. Early and advanced symptoms of effectiveness were carefully observed.

The efficacy for hack and squirt, capsule injection, and cut surface treatments on A. rubra were 98.8%, 97.3%, and 90.9% respectively.

Most cut surface treatments in the trials were 100% successful (Table 3). In two plots (Tower 106/3, Table 3) the treatment was

delayed by one day and glyphosate was subsequently applied during a rainstorm. Since this treatment procedure was contrary to specifications, the significance of the results in these plots is questionable. When treatment of the stumps followed cutting within seconds, total control was achieved.

Harrison Hot Springs (Permit #105-164* RES-81/84)

The summer hack and squirt program resulted in 98.8% control of A. rubra, the major target species, whereas the fall treatment at the Haney research forest (Permit #105-156-81/83) controlled 99.4% of A. rubra (Table 1). The site, prior to treatment, had a very high percentage of alder and some suppressed ground covers. Following treatment, there was a proliferation of shrubs and ground covers such as grasses, Pteridium aquilinum - bracken fern, Rubus parviflorus - thimbleberry, Rubus spectabilis - salmonberry, Rubus leucodermis - black raspberry, and Ribes sanguineum - red-flowering currant.

Haney Research Forest (Permit #105-156-81/83)

The results were comparable to plots at Harrison Hot Springs (Tables 1,4). A few R. leucodermis plants exhibited the wrinkled, dwarfed leaves symptomatic of responses to glyphosate. A. rubra was the predominant species interspersed with a considerable number of P. trichocarpa. The abundant shrubs and ground covers were represented

mainly by R. parviflorus, R. spectabilis, R. leucodermis, Salix spp - willows, and Juncus spp - rushes.

Agassiz Research Farm (Permit #105-157-81/83)

The control levels of capsule injection at the Agassiz site were 95.6% compared to 98.8% (Permit No 105-164* RES-81/83), and 97.3% (Permit No 105-165* RES-82) at the Harrison Hot Springs Site (Table 2). Grasses, Rubus procerus - Himalayan blackberry, Salix spp, Juncus spp, and various herbs were the dominant shrub and ground covers.

Control Plots

Dead trees were not found in the control plots adjacent to either the hack and squirt or the capsule injection plots.

The mortality of stumps in the controls for cut surface treatment varied from 47-82%. Field observations indicated that the lowest levels of mortality were in plots with an abundance of grasses and herbs, while the highest levels of mortality occurred in sites dominated by low-growing shrubs.

General Field Observations

Although the numbers were not recorded, the individual trees which survive are most frequently those with the largest dbh and trees with

notches above waist height or notched inadequately to girdle the stems. In some cases, callous tissue had surrounded the blackened area near the notch allowing the translocation of nutrients to preserve the tree.

The overall detrimental effects on desirable ground covers were negligible. A few R. leucodermis and R. spectabilis plants were observed with necrotic foliage and fasciated leaves. Flashbacks into other trees or ground covers were not found.

Field crews found the formulation containing the dye very safe. Inadvertent splashes were very noticeable and could be washed quickly. The dye would also clearly show environmental contamination through spills. The self-contained capsules exclude personal and environmental contamination. Accidental spills did not occur.

DISCUSSION

The tree injection and cut surface techniques are presently the state of the art for controlled, judicious vegetation management programs. The Lower Mainland, Fraser Valley and other coastal areas with their priceless aquatic resources, diversity of low-growing plant species, and populated areas are well-suited for selective, species-specific applications of herbicides. These techniques are completely compatible with the goals of contemporary ROW vegetation control since they promote the growth of desirable shrubs. The resultant seral communities effect

biological control by suppressing the development of the tall-growing species. When augmented occasionally by selective slashing or species-specific chemical treatments, this integrated vegetation management approach will require minimal control costs and basically be self-perpetuating (Bramble, W. C. and Byrnes, W. R., 1982).

Comparisons between species, sites, and techniques from the data collected (Tables 4,5) indicate that control levels exceeding 90% can be expected if specifications are followed. The reported values for the number of trees controlled have been conservative and include many trees where subsequent survival is extremely doubtful. Where trees have a dbh greater than 8 cm, improved control may be achieved by frilling the stem before injecting the herbicide since the hack and squirt and capsule injection techniques produce inconsistent mortality levels. Smaller stems are also a problem since hack and squirt or capsule injection may be impractical on small, flexible stems. This problem may be overcome by utilizing cut surface treatments.

Tree mortality was not found in the control plots for the injection trials. Most trees appeared to be growing vigorously with no evidence of serious pest infestations. A high level of mortality was observed sporadically in the cut surface treatment control plots, a characteristic which was not expected since it is very unusual for the study area.

Other aspects of the techniques, including worker and environmental safety, are practically flawless. Workers were reassured by the high oral and dermal LD₅₀ values for glyphosate of 4,320 and 7,940 mg/kg respectively (Miller, A. V. and Craig, S. M., 1980). They felt there was very little chance of contamination with any of the techniques. A few stunted leaves on R. leucodermis plants were observed. This occurred at a hack and squirt site which had been treated during a rainstorm.

Representative treatment areas were viewed by provincial and federal government experts. Their comments were very supportive of the program based on field observations. This report is intended to supply sufficient data for registration of these invaluable techniques.

CONCLUSION

Glyphosate injection was found to be efficacious on all species tested. The hack and squirt and capsule injection techniques applied to A. circinatum, A. macrophyllum, A. rubra, B. papyrifera, P. trichocarpa, P. menziesii, and T. plicata resulted in excess of 90% mortality. A greater level of efficacy may be achieved by more consistent compliance with specifications and by the inclusion of a frilling requirement for trees with a dbh exceeding 8 cm.

The cut surface treatment, with the exception of one improperly treated plot, showed 100% mortality. The control plots had mortalities ranging

between 47-82%. This high mortality of A. rubra cut stems is unexpected since, usually, the survival and regeneration of A. rubra following slashing programs is an enormous problem.

For the purposes of commercial vegetation control, neither the unpredictable variability nor the level of mortality is acceptable, since 100% mortality is needed on powerline tower sites. The results achieved for the cut surface application of glyphosate on A. rubra provide the required efficacy to achieve this goal.

Table 1. Control of target species by hack and squirt using 14% glyphosate

Plot number	Date treated	Date evaluated	Number of trees controlled/treated						
			<u>Alnus rubra</u>	<u>Betula papyrifera</u>	<u>Acer circinatum</u>	<u>Acer macrophyllum</u>	<u>Populus trichocarpa</u>	<u>Pseudotsuga menziesii</u>	<u>Thuja plicata</u>
Harrison Hot Springs Permit #105-165* RES-81/83 Tower #109/2-109/1									
1	1-8/07/82	14/07/83	58/60	10/10	2/2	N/A	N/A	N/A	N/A
2	1-8/07/82	14/07/83	21/21	N/A	N/A	N/A	N/A	2/2	N/A
3	1-8/07/82	14/07/83	34/34	5/5	N/A	N/A	N/A	N/A	N/A
4	1-8/07/82	14/07/83	12/12	4/4	1/1	N/A	N/A	N/A	1/1
5	1-8/07/82	14/07/83	40/40	5/5	2/2	N/A	N/A	N/A	1/1
Haney Research Forest Permit #105-156-81/83 Tower #139/4-140/1									
1	09-10/82	22/07/83	38/38	3/3	N/A	N/A	9/9	2/2	2/2
2	09-10/82	22/07/83	60/60	2/2	N/A	N/A	15/15	2/2	N/A
3	09-10/82	22/07/83	62/62	1/1	N/A	N/A	12/12	N/A	N/A
4	09-10/82	22/07/83	53/53	3/3	N/A	N/A	18/18	2/2	1/1
5	09-10/82	22/07/83	44/45	2/2	N/A	N/A	11/11	1/1	3/3
6	09-10/82	22/07/83	38/38	N/A	N/A	N/A	9/9	3/3	2/2
7	09-10/82	22/07/83	46/47	3/3	N/A	N/A	12/12	1/1	2/2

Table 2. Control of target species by capsule injection using 0.2 g of glyphosate per capsule

Tower number	Plot number	Date treated	Date evaluated	Number of trees controlled/treated							Pseudotsuga menziesii	Thuja plicata
				Alnus rubra	Betula papyrifera	Acer circinatum	Acer macrophyllum	Populus trichocarpa				
Harrison Hot Springs Permit #105-165* RES-81/83												
	1	7-15/10/82	15/07/83	57/60	5/5	6/8	50/51	N/A	7/7	15/16		
	2	7-15/10/82	15/07/83	39/40	10/10	9/11	13/15	N/A	4/4	6/6		
	3	7-15/10/82	15/07/83	20/20	3/3	3/4	18/20	N/A	N/A	N/A		
	4	7-15/10/82	15/07/83	21/21	2/2	7/7	7/9	N/A	N/A	7/8		
	5	7-15/10/82	15/07/83	33/34	7/7	6/7	10/10	N/A	N/A	8/8		
	6	7-15/10/82	15/07/83	49/50	7/7	3/3	18/20	N/A	3/3	10/10		
Harrison Hot Springs Permit #105-164* RES-81/83												
	1	1-8/07/82	07/14/83	58/60	10/10	2/2	N/A	N/A	N/A	N/A		
	2	1-8/07/82	07/14/83	21/21	N/A	N/A	N/A	N/A	2/2	N/A		
	3	1-8/07/82	07/14/83	34/34	5/5	N/A	N/A	N/A	N/A	N/A		
	4	1-8/07/82	07/14/83	12/12	4/4	1/1	N/A	N/A	N/A	1/1		
	5	1-8/07/82	07/14/83	40/40	5/5	2/2	N/A	N/A	N/A	1/1		
Agassiz Area Permit #105-157-81/83												
	1	5-6/12/81	26/07/83	47/50	N/A	4/4	31/35	4/4	N/A	N/A		
	2	5-6/12/81	26/07/83	31/33	2/2	2/2	26/28	1/1	N/A	N/A		
	3	29/11/81	26/07/83	28/28	2/2	2/2	28/28	2/2	N/A	N/A		
	4	15/11/81	26/07/83	30/31	N/A	1/1	13/14	N/A	N/A	N/A		
	5	8-14/11/81	26/07/83	18/18	1/1	N/A	9/9	2/2	N/A	N/A		
	6	8-14/11/81	26/07/83	22/24	N/A	2/2	15/17	N/A	N/A	N/A		

Table 3. Control of Alnus rubra by cut surface application using 14% glyphosate, Harrison Lake area, permit #105-165 *RES-81/83

Tower number	Plot number	Date treated	Date evaluated	Treated stumps no regeneration**/total	Non-treated stumps no regeneration/total
106/3	1	7-15/11/82	07/15/83	11/18	9/15
	2	7-15/11/82	07/15/83	9/13	8/17
106/1	1	7-15/11/82	07/15/83	17/17	16/20
	2	7-15/11/82	07/15/83	6/6	3/4
	3	7-15/11/82	07/15/83	7/7	8/10
105/3	1	7-15/11/82	07/15/83	15/15	12/20
	2	7-15/11/82	07/15/83	6/6	3/5
	3	7-15/11/82	07/15/83	19/19	9/11
	4	7-15/11/82	07/15/83	10/10	6/11
	5	7-15/11/82	07/15/83	10/10	7/11

* Research

** Stumps with no visible signs of pink dye were not tabulated.

Table 4. Efficacy of the hack and squirt treatment using 14% glyphosate mixed with inert thickeners and dye

Species	Number of trees controlled/treated	Remarks
<u>Acer</u> <u>circinatum</u>	N/A	none present in sites selected for study
<u>Acer</u> <u>macrophyllum</u>	N/A	none present in sites selected for study
<u>Alnus</u> <u>rubra</u>	506/510	excellent control; trees with large dbh most difficult to control
<u>Betula</u> <u>papyrifera</u>	38/38	excellent control; few trees with greater than 3 cm dbh in test site
<u>Populus</u> <u>trichocarpa</u>	86/86	excellent control
<u>Pseudotsuga</u> <u>menziesii</u>	13/13	excellent control; most trees on site too small for treatment
<u>Thuja</u> <u>plicata</u>	12/12	excellent control

Table 5. Efficacy of the capsule injection technique using 0.2 g a.i. glyphosate per capsule

Species	Number of trees controlled/treated	Remarks
<u>Acer</u> <u>circinatum</u>	9/9	stems usually very thin and difficult to penetrate
<u>Acer</u> <u>macrophyllum</u>	238/256	some trees survived producing fasciated leaves
<u>Alnus</u> <u>rubra</u>	395/409	some misjudgement of capsules/stem resulted in less than 100% control
<u>Betula</u> <u>papyrifera</u>	39/39	stems usually very thin and difficult to penetrate
<u>Populus</u> <u>trichocarpa</u>	9/9	
<u>Pseudotsuga</u> <u>menziesii</u>	14/14	
<u>Thuja</u> <u>plicata</u>	46/48	trees not controlled received insufficient number of capsules

Appendix 1. Scientific and common names of plants
discussed in the study

Scientific name	Common name
<u>Acer circinatum</u>	vine maple
<u>Acer macrophyllum</u>	bigleaf maple
<u>Alnus rubra</u>	red alder
<u>Betula papyrifera</u>	white birch
<u>Juncus spp</u>	rushes
<u>Populus trichocarpa</u>	black cottonwood
<u>Pseudotsuga menziesii</u>	Douglas fir
<u>Ribes sanguineum</u>	red-flower currant
<u>Rubus leucodermis</u>	black raspberry
<u>Rubus parviflorus</u>	thimbleberry
<u>Rubus procerus</u>	Himalayan blackberry
<u>Rubus spectabilis</u>	salmonberry
<u>Salix spp</u>	willows
<u>Thuja plicata</u>	western red cedar
<u>Tsuga heterophylla</u>	western hemlock

ACKNOWLEDGEMENTS

The diligence and dedication provided by Keren Sopel and Marilyn Petters of the Word Processing Section of B. C. Hydro was much appreciated.

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